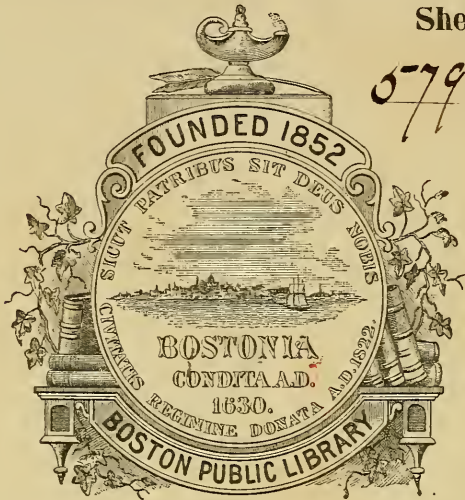


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ANÆSTHETIC AGENTS,

THEIR MODE OF EXHIBITION AND PHYSIOLOGICAL EFFECTS.

BY HENRY J. BIGELOW, M. D.

[Extracted from the *Transactions of the Am. Med. Ass.*, Vol. I.]  
C

THERE is no difference of importance in the general character of the insensibility or other symptoms resulting from the inhalation of *ether* and *chloroform*. The latter, whose discovery in this relation the world owes to Professor Simpson, is much more potent than ether, more palatable, and less irritating to the lungs.

*Chloric ether* was extensively employed by Mr. Lawrence, and has been since used by other experimenters. Its effects are apparently identical with those of common ether, than which it is if anything less powerful, while its vapour may be a little less irritating. Its odour is certainly more agreeable.

*Nitrous oxide* was employed by Horace Wells in his experiments. It was then found to produce exhilaration out of proportion to its inebriating properties. In order to place this gas in circumstances favourable for its complete effect, it should be furnished to the lungs as freely and as pure, as ether vapour from the evaporating surface of liquid ether. It should be supplied from a large gas-holder, and not from a small gas bag; and that portion of the gas which has been deprived by the lungs of its inebriating principle, should be exhaled as waste. Thirty quarts thus inhaled by myself produced complete but brief insensibility; and on the 26th of April, I removed a breast by the aid of about twice that quantity, consumed during six minutes, and producing a most tranquil and complete insensibility. Though bulky, nitrous oxide is quite likely to prove a certain, as well as safe, and agreeable anæsthetic agent, administered in the above manner, which I have not seen alluded to. In the case mentioned, the pulse, which Dr. Townsend was good enough to note

for me, rose from 90 to 120, and continued at that point during the operation.

*Aldehyde*, used by Monsieur Poggiale, although it is said to be stronger than chloroform, is also conceded to be more suffocating than ether, the odour of which it has. It is probable, therefore, that ether is the less objectionable of the two agents. It produces, says Professor Simpson, much bronchial constriction and coughing.

*Nitrate of ethyle*, upon the same authority, is also rapid and powerful in its effects; yet produces excessive noise and fullness in the head, with subsequent headache and dizziness.

*The bisulphuret of carbon*, a rapid and powerful anæsthetic, has "a peculiarly offensive smell of putrid cabbage."

*Benzoin*. The vapour of this liquid, of rather a pleasant aromatic odour, is said to be less powerful than that of chloroform. In the hands of Mr. Snow it produced in the patient certain convulsive tremors. The four last agents are "not comparable," says Professor Simpson, "with chloroform or sulphuric ether, either in their manageableness or in their effects."

By a rough estimate of the quantity consumed in operations, chloroform is eight times as strong as ether; and a drachm of the one or an ounce of the other, is a fair allowance for inhalation at the commencement of the process. As it evaporates, the fluid may be replaced if necessary.

The absolute necessity of interposing something between the lips and the inebriating agent, when the latter, like chloroform, irritates the skin, was quite over-estimated in the case of common ether; and the public attached as false a value to the inhaling apparatus, as to the stethoscope in a kindred science. In administering ether, an inhaling apparatus is occasionally convenient. The more complicated form, in all its modifications, contains as its chief element the double valve originally suggested by Dr. Gould; and a tube furnished with it may be dilated or constricted so as to represent almost all the principal inhalers in use.

For brief and repeated inhalation, and to avoid the odour of sulphuric ether, as well as to retard its evaporation, an inhaler is convenient; but for common purposes, a bell-shaped sponge is quite efficient, and is to be turned from time to time during an expiration, to bring the gravitating ether to the top.

With the introduction of chloroform the invention of apparatus received new impetus. Its stimulant, and even vesicating properties contraindicate the direct application of this fluid to the skin.

The simplest contrivance is the best, and Simpson's folded handkerchief rolled into a cone answers well for a brief inhalation. Channing's pasteboard cone, so cheap that each patient may have a new one, lasts through an average midwifery case; a lamp-chimney, stethoscope, or other tube containing a sponge answers equally the purpose, while for the rapid and complete insensibility required for surgical purposes, and for hospital use, some more durable form of apparatus is requisite. It should comprise a mouth-piece, a receptacle for the sponge, and a diaphragm to prevent the flow of the fluid towards the mouth.

It is optional whether the vapour enter the system simultaneously through the mouth and nasal orifices, or by the mouth alone, the nostrils being closed. It has been said, that the effect is more immediate when the nasal cavities are filled with vapour; but the difference in the time of inhalation, if any, is inconsiderable.

It is a striking fact, that in many of the first experiments both in this country and abroad, vapour was inhaled from a shut cavity or sac in which the contained oxygen must have been rapidly exhausted. If there is one condition vital to the safety of inhalation, it is that an *adequate supply of oxygen should be insured to the patient*.

Inhalation should be of atmospheric air impregnated with vapour, and not of vapour alone. Air should be conducted through the medium containing the inebriating agent, and not merely to and from a closed cavity.

The production of the brief insensibility which suffices for the extraction of a tooth, is rarely accompanied with danger or with embarrassing circumstances; but the administration of ether for a length of time in a surgical operation, demands much attention. Now it is difficult for the surgeon to attend at once to a dissection, perhaps remote from the head, and at the same time to satisfy himself of the adequacy and safety of the anæsthetic state; and it is therefore not improbable that the part of etherizing, especially for a length of time and to a considerable extent, will be soon recognized as involving an entirely distinct responsibility, from that of the surgeon who performs the operation.

Let a patient be now subjected to any of the ordinary modes of inhalation, with the view of inducing for examination, some of the ordinary phenomena of etherization. It is unnecessary either to extenuate or to dissemble the symptoms which occasionally occur during the approach or continuance of the anæsthetic state. Though alarming in connection with the causes which previous experience



had assigned to them, many of them are of comparatively trifling import as a sequence of an anæsthetic agent; while, on the other hand, a few comparatively quiet indications stand at the limit of vital endurance, and give notice of real danger. The order of experience,—a few type or model cases as they occur, will perhaps afford the readiest method of exposing these phenomena.

1. A patient courageously inhales the ether;—a term intended to include the chloroform. Soon the respiration becomes more rapid; the chest heaves; the lips are blown out with the expiration, and while the patient is manifesting unequivocal signs of enjoyment, the head suddenly falls to one side, and the individual during the next two or five minutes is insensible to pain in any form. He awakes suddenly, smiles, is surprised to find the operation, if one has been performed, over; has had a pleasurable dream, and experiences no ill effects. This is etherization in its most favourable form, less frequent than the next.

2. A second patient averts his head to cough; inhales again and again coughs; declares his inability to take the ether; yet perseveres. The trachea has now become less irritable; respiration is tranquil, and insensibility of rapid access. Such cases are quite common in the practice of the dentist.

3. A third subject makes grimaces, and getting exhilarated rejects the apparatus; but is still amenable to peremptory discipline; and being directed to be quiet and to close his eyes, is soon narcotized.

4. Yet not always at once. A large and muscular man, perhaps habituated to stimulus, sometimes modifies grimace into a demonstration of resistance; closes his lips and jaw firmly, and refuses to inhale; objects to verbal and other interference; at last becomes violent, and if athletic, requires the united force of several assistants to confine him.

Here is a sufficient reason for not attempting the etherization of athletic subjects when such aid is not at hand. I believe that the best practice in such a case is to confine the patient, and to apply the ether steadily to the mouth and nose. For some seconds, perhaps many, the patient may refuse to breathe; and bystanders unaccustomed to the phenomena, exchange significant glances. But if the pulse is good there is no real danger, and at last, exhausted nature takes a deep and full inspiration, which, while it aerates the blood, is laden with the intoxicating vapour; colour returns; and the patient falls back narcotized. Violent resistance is not common.

5. It is, however, less unfrequent for the patient to vomit soon



after the appearance of the signs of etherization; and partly from the exertion, and partly from the inspiration of fresh air, he may then recover sensibility.

6. Lastly, the signs of insensibility having been manifested, the operation is begun. In a few moments the patient partially regains his consciousness, and exhibits the unequivocal appearance of suffering, which may or may not be subsequently remembered; or without being violent, is wild and uncontrollable.

It will be observed, that in all these cases, ether was administered for a comparatively short time. The result of such brief inhalation is brief narcotism, either complete or incomplete. If inhalation be arrested at this time, the period of subsequent insensibility to pain varies from one to three minutes. This short or partial insensibility is adapted to the operation of the dentist, which is usually rapid; the instrument is applied, and whatever be the demonstrations of the patient, it accomplishes its purpose. Here are no important nerves to be severed, nor vessels to be wounded. But in a dissection, such as occurs in many surgical operations, especially in one of a formidable character, it is important that the subject of the operation should not hazard his safety by being liable to sudden and convulsive movements while the knife is dealing with the tissues. If the patient thus partially revives, assistance is not unfrequently required to confine him, and it is necessary to re-administer the ether; the whole interfering materially with the tranquillity of the operation, and the comfort of those concerned; perhaps endangering the welfare of the patient.

Although many operations were performed abroad, both in England and upon the continent, and at no remote date, upon patients yet capable of movement and resistance, yet there is an obvious want of safety in operating under these circumstances. Decided preference should be bestowed upon a condition of complete and passive narcotism, provided it can be produced with equal certainty, and is equally free from serious results.

Such a condition is quite possible, and a short time suffices to induce a train of symptoms indicative of it. Let the inhalation be continued beyond the period, during which the patient exhibits the earlier signs of narcotism. The muscles will be found gradually and completely to relax under its influence; and at a later period the inspiration becomes a snore. The patient exhibits no sign of consciousness, and is, in short, profoundly narcotized.

In the symptoms hitherto detailed, two stages of the anæsthetic

state will readily be recognized; the first embracing the phenomena of partial consciousness, while the second presents the indication of total insensibility.

These two stages of anæsthesia demand separate consideration.

**FIRST STAGE.**—The first stage is characterized, either by the incomplete or partial character of the narcotism or by its brief duration. These phenomena suggest the notion that the blood is insufficiently impregnated with ether, or that the vapour has affected a portion only of the circulating fluid, the influence of which upon the brain is soon counteracted by the arrival in the cerebral vessels of fresh and unadulterated blood. Such theory illustrates the degree and the duration of the phenomena attending such inebriation.

The first stage requires for its induction a comparatively small proportion of the ether vapour. Insensibility, if complete is brief, and the patient revives in a period varying from one to three minutes, commonly without nausea, headache, vertigo, or other sensations of discomfort. But in certain cases, and especially when either from pulmonary irritability, or want of determination on the part of the patient, the dose has been insufficient, and its inhalation by consequence protracted through a period of six or eight minutes, a different range of symptoms is presented. The patient may be bewildered, like a man waking from a deep sleep, or uncontrollable except by moderate coercion. At this time the pulse is natural, or yet more frequently accelerated, either from exertion, or perhaps it has not regained its normal standard after the unavoidable excitement of anticipation. Though in the first stage of anæsthesia we might expect the pulse to be accelerated, yet it often deviates but little from its natural standard. Nor is the pupil especially affected in this stage. The muscular fibre is yet animated by the nervous influence, and is generally somewhat rigid; the arm resisting flexion or extension. Occasionally it exhibits the phenomena of catalepsy, retaining any position given to the limb. In rare cases I have noticed the access of clonic spasm, local or general in its invasion. When the spasm affects the glottis, it gives rise to a peculiar symptom, to be alluded to hereafter.

To the first stage of anæsthesia belong those remarkable and unanticipated physiological phenomena, which seem to unlink the intimate connection between sensation and an intellectual recognition of it; between cognizance and memory; between will and action.



A patient, thus partially etherized, is said quietly to criticise the amputation of his own leg, or resists the dentist's instruments, and to appearance suffers, and yet remembers nothing of it; or remembers, but has not felt; or, which is unpleasant and fortunately rare, has felt but could not move. Such occurrences, familiar to the early history of etherization, have been somewhat less frequent, since the subject has been better comprehended. Yet at a comparatively recent date, partial consciousness of the patient during an amputation, for example, has been regarded as a circumstance of unforeseen occurrence, and not always amenable to ready influences.

The inconveniences of partial consciousness have been alluded to; and I am now especially desirous of exposing the advantages of a state of inebriation, during which the patient lies passive and motionless, exhibiting only the phenomena of deep sleep.

**SECOND STAGE.**—Such is the second stage of anæsthesia, essentially characterized and identified by muscular relaxation. Let the subjects of the last mentioned experiments continue inhalation. The arm, from time to time, when raised from the side, resists. Soon, however, it becomes flexible, and at last, falls passive and motionless. The voluntary muscles are now relaxed; and it is impossible at this moment to rouse the patient. This stage requires for its induction a considerable quantity of ether vapour, which may be presented to the pulmonary surfaces either rapidly in the course of two or four minutes, or a more diluted vapour may be administered during a protracted inhalation of many minutes. In the former case, anæsthesia is of rapid access, and in its most favourable form. But in the latter, the dilute and protracted inhalation is often accompanied with the annoyances of partial anæsthesia, and it will be stated in another part of this paper that other symptoms, especially that of vomiting, are quite apt to interfere with inhalation before the inebriation has reached its second stage. The commencement of this state of narcotism, characterized by passive flexibility of the arm, suffices for any brief surgical operation, which is not likely to be impeded by the movements of returning sensibility. Yet this insensibility at its inception, though complete, is brief, and the revival of the patient often sudden.

A few additional inhalations so impregnate the system with the vapour, that revival is deferred for some minutes after the inhalation of pure air. Ether is this way cumulative in its effects. Besides this, recovery is then generally not instantaneous, but gradual



and preceded by the signs of returning consciousness, which indicate the readministration of the anæsthetic agent, and enable the surgeon thus to anticipate interruption. Protract the inhalation yet a little longer, and the inspiration becomes a snore; the pulse, which may or may not have been previously accelerated, beats slowly; while the pupil is frequently, though not invariably dilated.

Some little familiarity with these phenomena is required to enable the surgeon so to graduate inhalation as to continue the patient in this state of tranquil and deep sleep with safety.

There is no doubt that it can be done if necessary. I have frequently myself maintained insensibility nearly or quite complete for thirty minutes, and even for a longer period. While the snore is heard, the patient does not revive; yet the snore is an unnecessary symptom, and is an indication for the temporary suspension of inhalation, when a few inspirations of unadulterated air soon re-establish quiet respiration; and the patient is liable, at any moment, to swallow or give other indication of approaching consciousness. The cumulative effect of ether, before alluded to, is at this time to be borne in mind. Young subjects, too, require less than adults; so that after eight or ten minutes of insensibility in the adult, or a considerably shorter period in the young subject, the system has been impregnated with ether, and inhalation may be discontinued even before the snore is heard, without apprehension that the subject will rapidly recover. The signs of returning consciousness are the limit on one side of that degree of anæsthesia, which it is important to maintain during most surgical operations, and are indications for the reapplication of the inebriating agent, when it is desired to protract insensibility.

At the other limit of the second stage of anæsthesia, is a far more important indication of over-narcotized vitality; and here is the protection against danger. Without this safeguard, I conceive that it might well be hazardous to overshadow animal existence by this mysterious and powerful agency. The sign is *the diminution of the force and frequency of the pulse*.

In a case of the early administration of ether, at which I was present, and which has been reported, the danger from over narcotism was quite as imminent as in any case, not fatal, I have seen since alluded to. As a bystander, on that occasion, I casually felt the pulse, and found it barely distinguishable; and though it subsequently still decreased, the means at once adopted for the restoration of the patient, proved ultimately successful. This occurrence pointed

to the pulse as an indication of the stage of narcotism; a few subsequent experiments confirmed the opinion; and I have not since hesitated to push etherization to complete insensibility, and to continue it, if necessary, during a length of time, provided the pulse remained full and strong. If it be retarded, it is curious to observe with what certainty it recovers force and frequency, after a few inspirations of pure air. It will be inferred from these remarks that the pulse is to be carefully examined during the whole anæsthetic process, and that inhalation is to be temporarily discontinued at its indication.

Briefly to recapitulate, the first insensibility, partial though it be, suffices for the dentist. It exhibits the intellect and sensibility in novel and singular relations; while muscular force may or may not be impaired. Nothing is here infallible in pulse or pupil.

The second stage is of great value, and often essential to the surgeon. It lies between the signs of returning consciousness on the one hand, and the decreasing pulse on the other. It is ultimately accompanied by snoring inspiration, and the partially dilated pupil; which, together with the period of time necessary for the cumulative effect of ether, may be considered, each, as an additional indication for the temporary suspension of inhalation.

*Signs of Narcotism.*—The eyes are usually closed during inhalation. Let the patient be directed to open them. If etherized, he takes no notice of the voice. Perhaps the head droops; or the hand supporting the inhaling apparatus falls. These, alone, are signs of narcotism, which may be incomplete; or, if complete, temporary in its duration. If, in such a case, the arm of the patient be raised from his side, it is quite likely to resist the effort; or when raised, remains extended; phenomena indicative of partial narcotism. If inhalation be now suspended, the patient soon regains his consciousness; either manifesting unequivocal signs of pain, or resisting interference, during the half conscious state which often precedes recovery.

It should be added, that if the patient has inspired a good dose, and for a length of time, the dentist may consider any unusual manifestation, as an indication of but partial sensibility to sudden pain; protracted inhalation may be even taken as its priori evidence.

One of the early and occasional consequences of inhalation is a passive cessation of the respiration, while the pulse continues good. At this moment a tooth may be painlessly extracted; but as the vapour has now temporarily ceased to gain access to the lungs, the patient may revive before the next inspiration.

Muscular relaxation; the temporary loss of muscular contractility; the passive flexibility of the arm; is the most valuable sign of complete narcotism. It is succeeded by snoring inspiration and slow pulse.

*Signs of returning consciousness* are, swallowing, coughing, moaning, an effort to articulate, and muscular movement.

*Rapidity of access of the Anæsthetic State.*—Somewhat modified by the strength and temperament of the individual, the rapidity with which the system yields, is generally in direct relation with the dose administered. The maximum dose will be again discussed under the head of dangers; but it may be here stated that many of the unfavourable symptoms owe their existence to the protracted inhalation of an inadequate dose; while after the first irritation of a large volume of vapour at once introduced into the air tubes has subsided, the patient yields tranquilly, and is much less liable to disagreeable and annoying symptoms.

*Vomiting* is especially connected with the long duration of the inhalation, and also with its inadequacy. So, also, is general excitement, and resistance; and probably spasm, whether of the vocal chords or of the muscular system generally.

The common imperfections of the inhaling process are, the use of too large a sponge for ether, and of too small a sponge for chloroform. The former distributes and evaporates the ether rapidly, while its interstices admit a good deal of air. The latter will not detain an adequate amount of chloroform without endangering the patient's skin. If the sponge be previously wrung out in water, its capillary attraction is increased.

#### ANÆSTHETIC SYMPTOMS CONSIDERED SEPARATELY.

*Intellectual Phenomena.*—It is said that a patient may take cognizance of the amputation of his own leg. This occurrence I have never seen, though it is far from improbable. It implies a distinct recognition of surrounding objects through special sense, at a moment of complete insensibility to pain in its severer forms. Such complete insensibility is more frequently attended with entire disability of special sense; yet sensation may be partially annulled, and the patient continue quite cognizant of the external world.

The manifestation of acute suffering, and even of well-directed resistance, may occur without the patient's subsequent remembrance of it. Here the faculty of memory is extinct.



Or memory may recall the manifestations of an operation of which it has forgotten the sensations. And it is said that cognizance and memory may be distinct, while the machinery of muscular action is deranged.

*Mental excitement*, hilarious or hostile, is not uncommon in an early stage of narcotism, and is materially influenced by its rapidity.

*Pulmonary irritability* varies with the individual.

Chloroform is less irritating to the lungs than ether, and so, perhaps, is chloric ether.

Violent cough is occasionally excited by a small quantity of vapour, while a much larger quantity may occasion none; but by a little careful graduation of the first few inspirations, the patient may be saved much unnecessary irritation. Soon pulmonary sensibility is narcotized, and the patient breathes quietly. Even habitual dyspnœa, or the paroxysm of asthma, is temporarily solaced by this agent. As the process is continued, the trachea becomes insensible to the presence of fluid, whether blood from operations near the mouth, or the increased natural secretions of the pulmonary surface.

*Nausea and vomiting* are not uncommon sequences or concomitants either of partial or complete anæsthesia; nor, beyond their interference with the progress of the inhalation, and with the mere comfort of the patient and of the operator, are they objectionable. They are allied to the nausea induced by other narcotic and inebriating agents, and have especial relation with the duration of the anæsthetic process.

*The snoring inspiration* indicates profound sleep. Varying a little in the facility of its production in different individuals, it is a constant phenomenon of a certain stage of narcotism. While it is often desirable to induce this symptom, its exhibition renders further inebriation unnecessary for the moment. It is always accompanied with muscular relaxation, and soon succeeds it. It results from the relaxation of the muscles of the palate; and in this connection it is desirable to distinguish it from another symptom, of somewhat different signification, viz:

*Stertorous respiration*, due to spasmodic action of the vocal chords, and allied to the spasmodic action of other muscles. It is somewhat rare in its occurrence; once heard, it will be readily recognized, and indicates a brief suspension of the inebriating process. Though of itself, it is quite unimportant, yet as the immediate cause of another symptom, it deserves further consideration. The closure of the

laryngeal aperture shuts off the supply of atmospheric air from the pulmonary tubes. The same condition results from the voluntary closure of the mouth and lips; but the last soon yields, while the spasm of the glottis gives rise, in rare cases, to a partial asphyxia, indicated by the then livid colour of the cutaneous surface. Similar lividity is often exhibited during a spasm of whooping-cough or in a hysteric fit, and is of comparatively slight importance, from the fact that when the system feels peremptorily the necessity for air, the spasm resulting from the anæsthesia relaxes, the patient breathes freely, and the blood is aerated. Two or three inspirations suffice to restore to the cheek its natural colour.

*Muscular System.*—The ordinary affections of the voluntary muscles have been alluded to. Organized resistance resulting from nervous excitement; tonic and clonic spasm; the cataleptic state being not unfrequent; while in one case I observed a convulsive effort of the whole system of voluntary muscles.

Other muscles are partially affected. The sphincters very rarely lose their contractility. It is well known that the uterus contracts during partial and even complete unconsciousness; a diminution of cessation of its contractile action being the rare exception and not the rule. The respiratory muscles play tranquilly during narcotism, while the heart, losing the force and frequency of its pulsations, slowly ceases to beat, in its latest and profoundest stage.

• *Pulse and Pupil.*—Incidental excitement usually accelerates the pulse, the relative frequency of which, during the earlier stage, it is difficult from this circumstance to estimate. It does not lose either in force or frequency until the whole system is profoundly narcotized. It is then, as at other stages of the process, a most valuable indication of the condition of the nervous system, and ultimately of the limits of vital endurance.

The pupil, though commonly at first contracted, and subsequently dilated, is less to be relied on as an indication.

*Prolonged insensibility* is quite exceptional and rare. In the case of a young woman, of the details of which I am cognizant, such insensibility ensued upon a brief recovery of the ordinary character, and after the ordinary interval. The patient then again became insensible, apparently without cause, and slept heavily, in spite of efforts to arouse her, during an hour. The symptom which excited apprehension, was the smallness of the pulse, which at times was barely perceptible at the wrist. This patient ultimately recovered, as I believe, have all others similarly affected. The phenomena sug-



gested those occasionally presented after an amputation, when the patient awakes in acute suffering, and again spontaneously sleeps while stitches are inserted.

A few phenomena only remain to be noticed.

*Convulsions* have been reported, occurring at the interval of many hours after inebriation.

A gentleman of Providence informs me that he has suffered for many months from *vertigo*, *headache* and *disability for labour*, which ensued upon a dose of ether vapour.

Such cases, with others which have been detailed, must be considered as exceptional, due to peculiar and individual susceptibility, and they are also of exceeding rare occurrence.

It may be convenient to arrange etherization under several distinct heads, adapting its degree to the character of the surgical operation for which ether is to be administered.

1. *In amputations and other brief surgical operations, and in the extraction of teeth.*—In this latter case, inhalation may be discontinued a few moments after insensibility. In the former, it is better to continue it two or three minutes longer, and till muscular relaxation. For the extraction of teeth, the patient may himself retain the sponge. When the hand wavers, or falls, the mouth is carefully, but if need be, forcibly, opened, without loss of time, and the forceps are at once applied. In this way one or more teeth may be removed while the patient is in an unconscious or half conscious state, but free from pain.

2. *Protracted dissections* may be commenced a short time after insensibility; the sponge being continued to the mouth, with an occasional interval to insure the patient ample supply of oxygen. When there is snoring respiration, the sponge should be removed during the short time required to re-establish quiet inhalation. The pulse is kept in hand, and any diminution of its frequency or force, especially the former, is an indication for the admission of unadulterated atmospheric air. Forty-five minutes is a somewhat unusual duration of insensibility, and is not to be attempted by those not conversant with the process. It is important to the operator, in these cases, that the patient should be fairly narcotized, and with a little experience with a rigid attention to the above precautions, accident need not be apprehended.

It may be added that much of the pain of a dissection is not of an acute character likely to arouse the patient; so that after some time has elapsed, a state of semi-consciousness often suffices; the vapour



being then applied, either during the intervals of the operation, or as manifestations of pain or resistance may present themselves.

3. *Hare-lip*.—With this operation may be included others upon the nose and mouth, fauces and trachea. It has been presented as the type of such operations, because it embraces several particulars of interest. An operation in this region is often a dissection, and of the parts concerned in inhalation. It is, therefore, impossible to continue this process during manipulation. If, then, in such a case, the patient is to remain insensible, the surgeon has two alternatives; one of profoundly narcotizing the patient in the first instance; the other of re-administering the ether; often at an inconvenient moment, and when the operation is materially interfered with. Of these alternatives, the former seems to me the least objectionable. Another important feature in these operations, is the liability of the blood to accumulate in the trachea, which is no longer irritable or conscious of its presence. When a tracheal rale gives indication of the collection of a considerable quantity of blood or other fluid in this region, the patient should be made to lean forward, to facilitate the natural expulsive efforts of the expiration or of the cough, as consciousness returns. In general during operations upon the face and jaw, under the influence of ether, the patient should be sustained in a position inclining somewhat forwards, and care should be taken to prevent, as far as possible, by sponges or otherwise, the recession of blood into the buccal cavity. Protracted operations upon the fauces are difficult, if not impracticable, with the use of ether. On the other hand, the admission of instruments to the trachea, especially from the outside, is, without doubt, thus facilitated.

4. In *dislocation*, it is obvious that ether inhaled, can be of no avail unless continued to the relaxation of the muscles.

It is well known with what facility dislocation is reduced upon the dead subject; and it is quite probable that all recent and favourable cases in the living subject may be reduced with almost equal facility, when muscular relaxation is completely effected. This is confirmed by one or two cases of dislocated shoulder, which have fallen under my notice. I have met with no case of recent dislocated hip since the introduction of the anæsthetic agents. It would be desirable, in such a case, that an attempt should be made completely to annul muscular resistance, before efforts are directed to the replacement of the bone.

It is equally evident that the reduction of hernia can be facilitated only by muscular relaxation, and that anything approaching

to spasm would aggravate the difficulty of reduction during its access.

Lastly, ether has proved of service in abating the spasm of stricture, in lithotrixy, and in the breaking up of adhesions resulting from fracture near the joints. Yet in the latter cases pain has always offered sure indication of the advisable extent of the respective operations, and in its absence, considerable discrimination is to be exercised. I have myself seen an arm refractured by an attempt to overcome the resistance of a mass of callus, after the adhesion of the articulating surfaces had yielded.

*Age.*—Experience shows that no especial ill effects result from the administration of ether to patients of average physical force at almost any age. Though I have operated on a child of three months, who was so far inebriated that its cries were modified into a sort of moan, yet I know of no case in which a young infant has been completely narcotized after its birth. Indeed, the facility of controlling a child of this age, together with the fact that it has neither the anticipation nor remembrance of suffering, however severe, seems to render this stage of narcotism unnecessary.

*Antidotes.*—It has been well said that fresh air, and in an extreme case artificial respiration is the best antidote to ether inebriation.

The symptoms of spasm, vomiting, &c., generally subside when the patient is left to himself. When the pulse is small and slow, this state of *narcotism* must not be identified with that of *syncope*. Brandy and other diffusible stimulants, appropriate remedies for syncope, belong to the class of agents which induce the anæsthetic symptoms; and it is quite probable, though evidence is yet incomplete upon this point, that the difficulty would only be aggravated by their use. Besides, the patient cannot always swallow. Cold water, dashed upon the face, or injected into the ears, undoubtedly aids in arousing the patient from the common ether narcotism. Galvanism to the precordial region has been suggested as a remedy in an extreme case; and it may be a question whether rest in the recumbent posture or active exercise, as adopted for the restoration of subjects affected with narcotism from opium, be best adapted for these cases. If any fluid is to be administered internally, analogy would suggest strong tea or coffee.

*The nature of the anæsthetic state* is a question of considerable interest. Perhaps the most satisfactory evidence upon this point, is that afforded by the analogy between the symptoms resulting from ether vapour in the lungs, and those of alcohol in the stomach.



Both, in small quantities, produce exhilaration. Both, in a large dose, produce the phenomena of dead drunkenness, and both, insensibility to pain. With alcohol, the state persists, while the fluid remains in the stomach; and patients have been at once aroused by the use of the stomach pump. In like manner anæsthesia continues, while ether vapour fills the lungs; respiration pumps the ether vapour from that receptacle, and gradually aerating the blood, terminates the anæsthetic state. Alcohol is found in the blood by chemical analysis; ether is equally detected in it by its peculiar odour.

Convulsions have been noticed in rare connection, both with ether and with alcohol. Finally, there is in ordinary cases, no great solicitude for the safety of a patient who is dead drunk, and experience has shown that ether narcotism is very rarely accompanied with danger.

Time does not serve for an analysis of the evidence relating to the effect of ether upon the different portions of the nervous system; nor is this evidence of a conclusive character. There may be some connection between the spasm, occasionally produced by alcohol and ether, and that induced by opium, alluded to by Todd and Bowman, resulting from polarity of the spinal cord, in cold-blooded, and even in warm-blooded animals.

Upon the same authority spasm of the glottis is among the results of irritation of the medulla oblongata. On the other hand, the medulla oblongata has been considered by Flourens, who claims this point as his discovery, to be the last stronghold from which life is driven by the anæsthetic agent. The animal then dies. Yet spasm of the glottis is not a formidable symptom.

The details of experiments in this obscure branch of physiology may be found in the papers of Flourens and of Longet, and may be compared with the intellectual phenomena elsewhere alluded to in this paper.

*Dangers.*—It remains only to speak of the dangers of the anæsthetic state. From this category, the symptom of asphyxia may be rejected; this being an evil easily anticipated, when due to an imperfection in the process; to the non-admission to the lungs of oxygen. Gradual and overwhelming narcotism may also be anticipated and arrested. The danger arising from the specific effects of an inebriating vapour in the pulmonary tubes may be considered, 1, as a question of experience and fact; and 2, of analogy and probability. As to the fact, I have been unable to find any fatal case



clearly resulting from the inhalation of ether, until the very recent one at *Auxerre*, apparently resulting in part from convulsions improperly treated, and in part from a neglect of the indications which the pulse affords. Of this case the details are imperfect. Deaths, like those reported by Nunn and Robb, occurring at an interval of twenty-four hours or more after the operation, may or may not have been accelerated by ether; which does not prevent, nor is to be considered responsible for, the ordinary collapse resulting in certain states of the system, after certain injuries and certain operations. The strong argument in behalf of ether is, that so few opportunities have occurred in which it could be even suspected of agency in fatal results.

With chloroform the evidence is a little different. Two somewhat remarkable cases of death, occurring during the brief administration of this agent for surgical purposes at once present themselves. The Cincinnati case and that of Mr. Meggison at Winlaton. In these cases death occurred in about five minutes from the beginning of the inhalation. In the Cincinnati case the quantity inhaled must have been considerable, from a saturated sponge in a four inch glass globe; yet in Meggison's case a drachm only was applied upon a handkerchief. It is quite possible that death resulted in the latter case, as Mr. Simpson avers, from asphyxia produced by the administration of brandy and other liquids before the patient was able to swallow. Such error would be easily avoided. Yet these instances suggest a specific cause of danger. This is the sudden impression upon the system of a powerful inebriating agent. Abundant alcoholic stimulus has often produced immediate death; and analogy would suggest that inebriating vapour in the lungs may be the equivalent of similar fluid in the stomach; and that in one or both the cases alluded to, chloroform may have produced a sudden and overwhelming shock upon the system.

Apart from the somewhat obscure case, before alluded to, there is no authentic evidence that sulphuric ether has been a cause of sudden death; and there is little doubt that this immunity from danger in its use is due in part to the comparatively moderate degree of its inebriating property, and in part to its volatility. Chloroform is much stronger than ether, while it is less volatile; so that although the vapour of a few drops may only give rise to moderate symptoms, and then escape by exhalation, that of a large quantity whose volume the lungs might easily contain, might powerfully impress the system, while the delay of its evaporation would materially

enhance its cumulative effects. Such theory suggests a consideration of practical importance. That in the use of chloroform a moderate dose should be inhaled gradually and not at once.

It is obvious, too, that the agency of heat to promote its evaporation, must increase the chance of danger. I think it may be laid down as a rule that a drachm of chloroform, at ordinary temperatures, suffices for a gradual inhalation of three minutes in the average adult. In recognizing a possible danger from an instantaneous and powerful dose on the one hand, it must not be forgotten that many of the unpleasant symptoms of the anæsthetic state are undoubtedly induced, and aggravated by protracted and futile attempts to produce insensibility, with an insufficient dose. Experience shows that after the first few minutes, and with due regard to the condition of the pulse, it is safe to increase the quantity of ether or of chloroform, until the inspired air is fully saturated, and the patient fairly narcotized.

If there is any one consideration calculated to arrest attention in the history of etherization, it is, that although the anæsthetic agents have been open to liberal use in every part of the civilized world, whether experimentally, ignorantly, or carelessly; although thousands have experienced their good effects; and although the physiologist, the ether opponent, and the coroner, have been equally ready to seize upon and to exaggerate any case of accident that might seem to fall within their range; yet it is probable that the number of cases, thus publicly suspected, have been less than ten, while the only conclusive instance of direct relation between an anæsthetic agent and death are two in number. Can antimony or opium show as clean a bill of health for the same period?





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